Reply Exhibit D

Quantifying the relationships between stream phosphorus concentrations and drainage basin characteristics in an agricultural watershed
- Cox, Engel, Olsen

1. Introduction
    - Brief explanation of eutrophication, role of phosphorus, importance of small streams in delivery of nutrients
    - Literature references on impacts of agriculture on water quality (nutrients)
    - Description of event mean concentrations and their utility.

2. Study Site
    - Background on Tenkiller, current and past uses, eutrophication history
    - Describe landuse within watershed -> particularly poultry farming and un-regulated waste disposal practices (including 2 mile radius rule)
    - Map of watershed.

3. Methods
    - Describe automated samplers
    - Selection of sampling sites (stratified design, un-impacted by point sources)
    - Event sampling program (frequency, duration, triggers)
    - Baseflow sampling
    - Sample retrieval
    - Flow compositing
    - Laboratory analysis methods
    - GIS and aerial photo data (including house densities and 1, 2 mile buffers)
    - Regression analysis
    - Synoptic sampling

4. Results
    - Tabular summary of sampling program (number of events, number of samples at each site…)
    - Tabular summary of landuse characteristics of sampled basins (all of the potential predictor variables looked at)
    - Example hydrographs with sample times
    - Tabular summary of R2 and p values (all variables)
    - Graphs of best linear regressions (AHD – 2mi ?) for both high and base flows
    - Do we need to do any further analysis to strengthen these results? Uncertainty bands etc?
    - Graph of cross correlation between septic tanks and AHD, with discussion of mass balance calcs of insignificant septic contribution ? (do we want to include all of mass balance calcs from Meegan et al?)
    - Synoptic snapshot bar graph.

5. Discussion
    - Discuss correlation with poultry operations
    - Discuss observed differences between baseflow and highflow concentrations
    - Discuss causes of variability in data but why the long term averaging approach gets past the variability
    - Discuss mechanisms for delivery of phosphorus from poultry
    - Discuss ramifications of strong correlation to poultry house density
    - Discuss possible management practices that could reduce impacts
    - Mention point source impacts as another source of phosphorus in the watershed not quantified here.

Abstract
Total phosphorus event mean concentrations were quantified for tributaries in a eutrophic watershed during a two-year intensive sampling program. Automated samplers were used to obtain flow-weighted composite stream samples associated with storm events for small tributaries, un-impacted by point sources, throughout the watershed. Base flow samples were also obtained from the tributaries during multiple dry weather sampling events. GIS mapping and aerial photography were used to investigate for possible correlations between various drainage basin characteristics and measured storm and base flow phosphorus concentrations. Results show strong and statistically significant positive correlations between total phosphorus concentrations and the intensity of poultry farm operations upstream of sample sites for both storm and base flows. Significant positive correlations were also found between phosphorus and upstream density of septic tanks. However, separate analyses show these correlations to be primarily an artifact of cross-correlations with poultry farm presence, rather than a true causal relationship. No other statistically significant correlations were discovered. A supplemental synoptic sampling event further demonstrates the impacts of poultry farming practices on stream water quality.

Results:

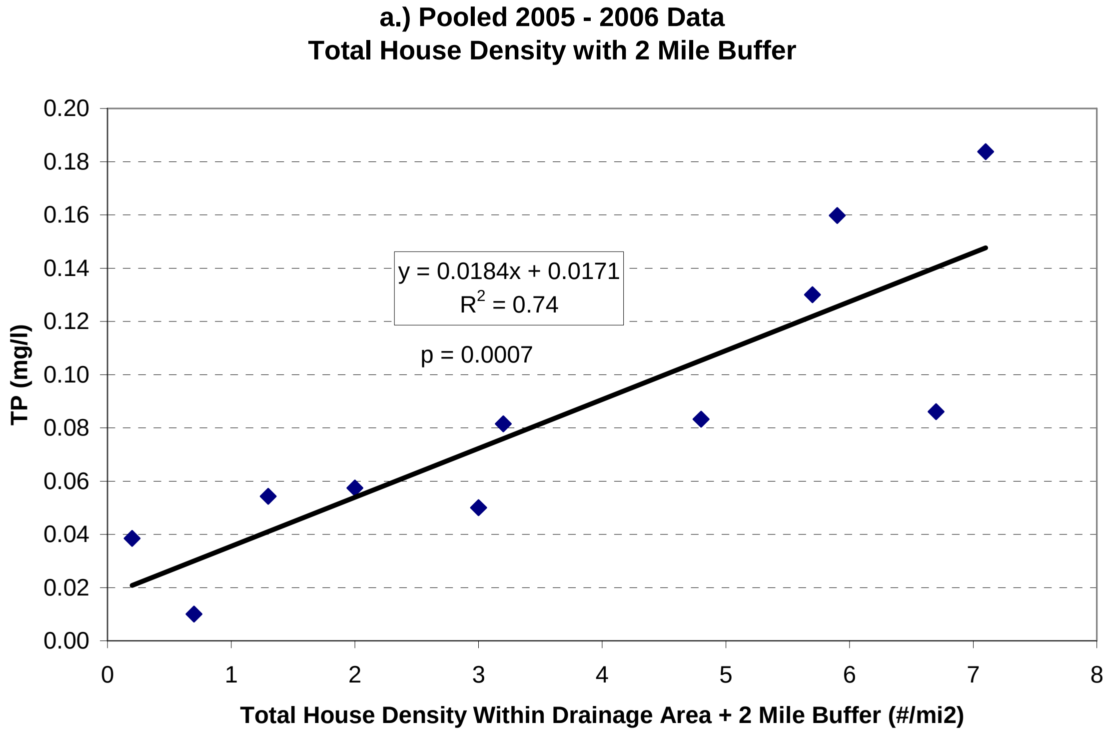
Table 6.7-1
Potential Total Phosphorus Predictor Variables

Variable	*Description*	*Rationale*
Total House Density (THD)	density (houses per mi^2) of all identified poultry houses, including inactive houses, in sub-basin	poultry waste is spread on fields in vicinity of poultry houses *(expected positive correlation)*
Active House Density (AHD)	density (houses per mi^2) of all identified active poultry houses in sub-basin	“”
THD – 1 mile buffered	density (houses per mi^2) of all identified poultry houses in sub-basin plus 1 mile	tributary water quality may be impacted by poultry houses a short distance outside of sub-basin (waste

	perimeter buffer	transported from a house outside the basin to a field inside the basin) *(expected positive correlation)*
AHD – 1 mile buffered	density (houses per mi^2) of all identified active poultry houses in sub-basin plus 1 mile perimeter buffer	“”
THD – 2 mile buffered	density (houses per mi^2) of all identified poultry houses in sub-basin plus 2 mile perimeter buffer	approximately 80% of poultry waste is spread on fields within 2 miles of poultry house (reference??) *(expected positive correlation)*
AHD – 2 mile buffered	density (houses per mi^2) of all identified active poultry houses in sub-basin plus 2 mile perimeter buffer	“”
SCS CN	Soil Conservation Service Curve Number	sub-basins with varying runoff potential may differ in their impact on receiving stream water quality
Septic Tank Density	estimated density (tanks per mi^2) of septic tanks in sub-basin	leaching from septic tanks may carry a significant phosphorus load *(expected positive correlation)*
% Pasture	percent of pasture in sub-basin	amount of pasture in a sub-basin can serve as a surrogate for agricultural activity which may be a good predictor of stream phosphorus concentration *(expected positive correlation)*
% Riparian Buffer	percent of stream length in sub-basin that is buffered by forest	riparian buffers can filter nutrients from runoff prior to entering streams *(expected negative correlation)*
Median Distance to Chicken Houses	median of distances (mi) from poultry houses in the sub-basin to the sampling site	poultry houses closer to the stream may have a greater impact on water quality than those further away *(expected negative correlation)*

Table 6.7-2 Regression Analysis Results Summary[1]		
	2005 – 06 Highflow	**2005 – 06 Baseflow**
THD	0.76	0.68
AHD	0.56	0.47
THD – 1 mi	0.65	0.3
AHD – 1 mi	0.49	0.19
THD – 2 mi	0.74	0.36
AHD – 2 mi	0.74	0.36
SCS CN	0.23	0.27
Septic Tanks	0.37	0.41
% Pasture	0.12	0.01
% Rip. Buff.	0.18	0.12
Med. Dist. CH	0.04	0.001

1 = statistically significant correlations ($p \leq 0.05$) indicated by yellow highlighting



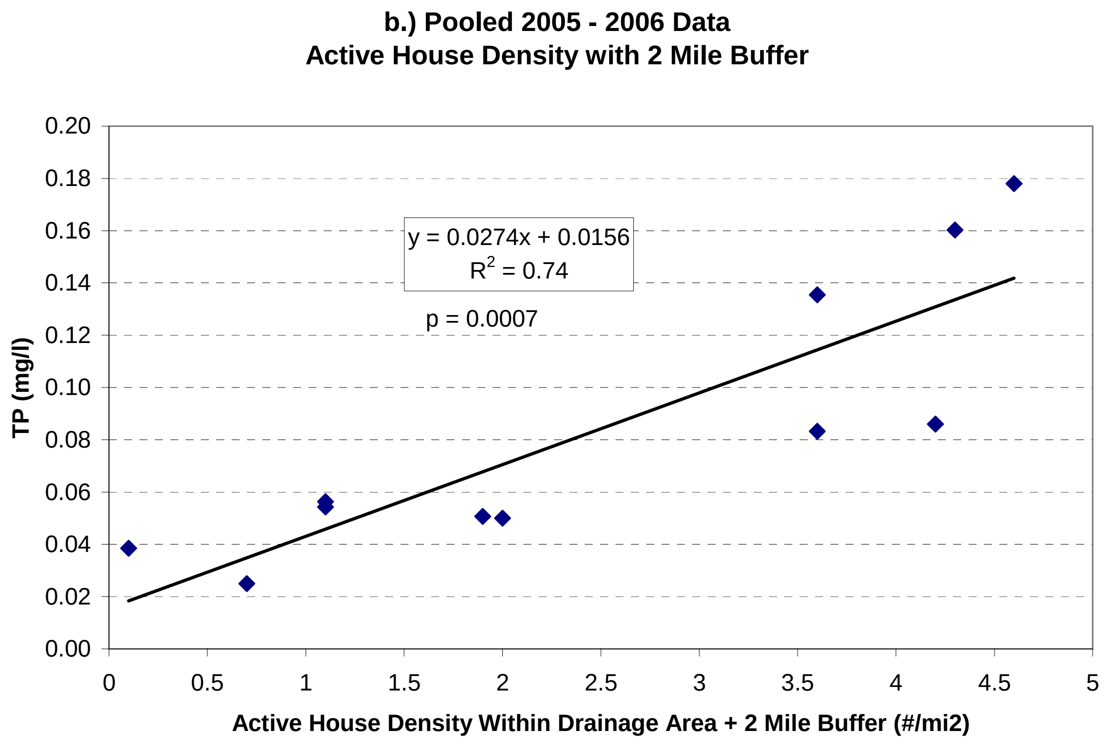
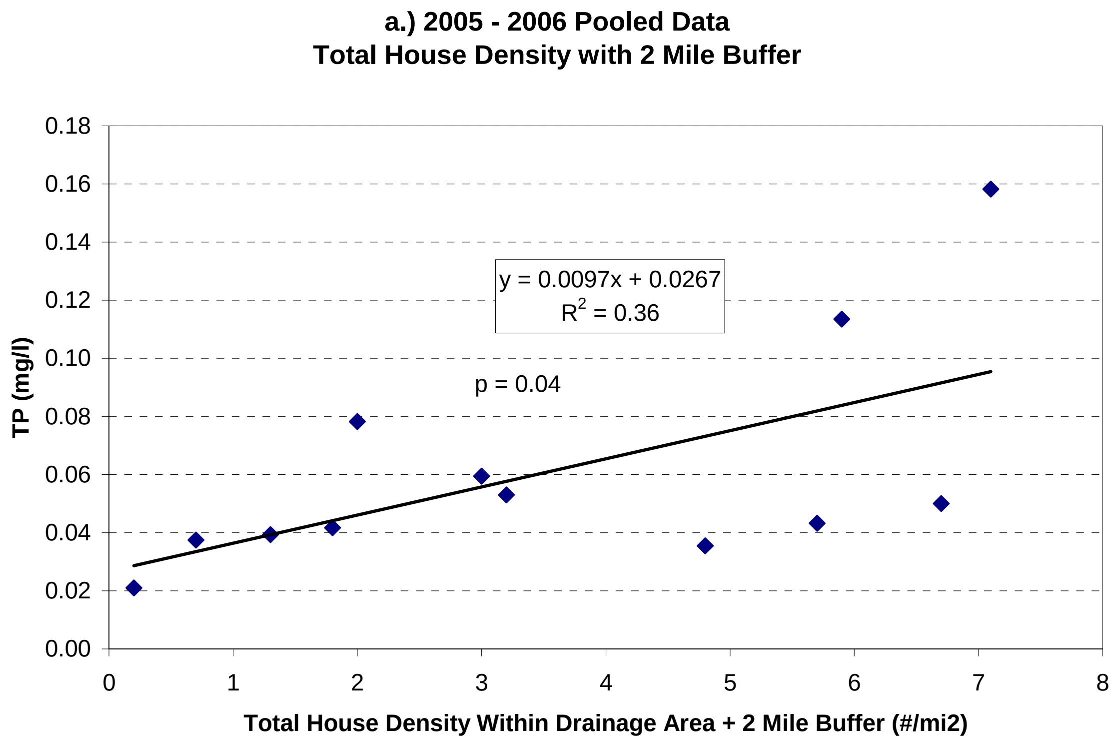


Figure 6.7-1
Highflow Regressions: Total Phosphorus Concentration vs. Poultry Presence



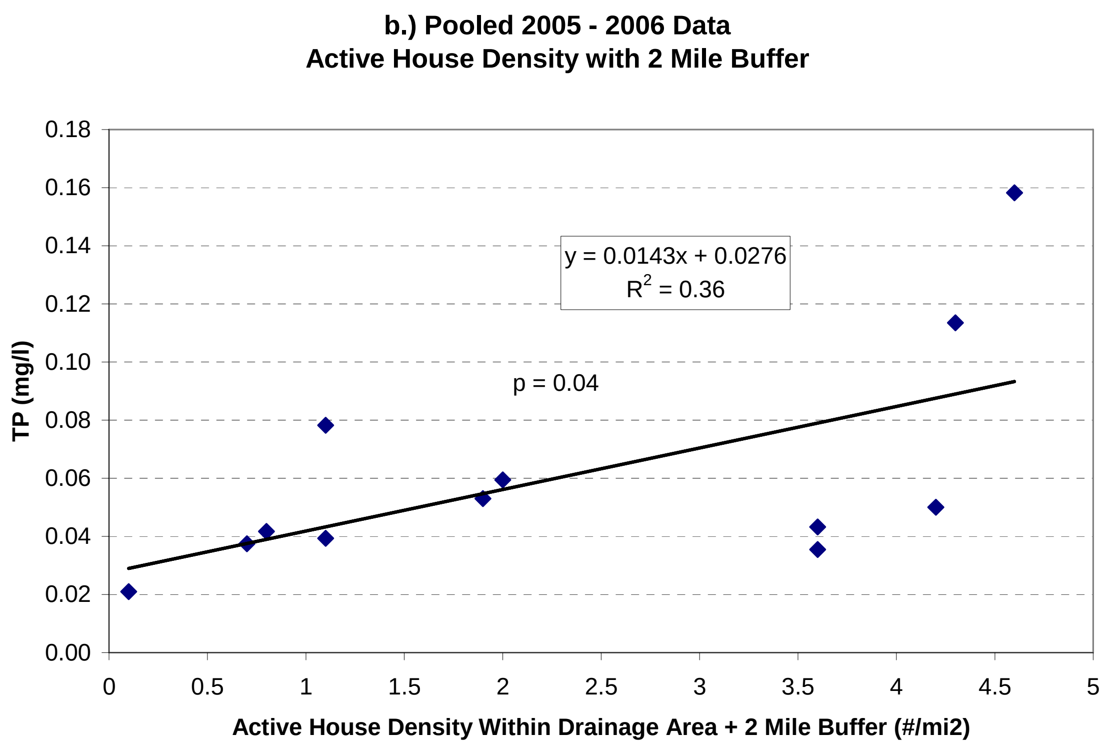


Figure 6.7-2
Baseflow Regressions: Total Phosphorus Concentration vs. Poultry Presence

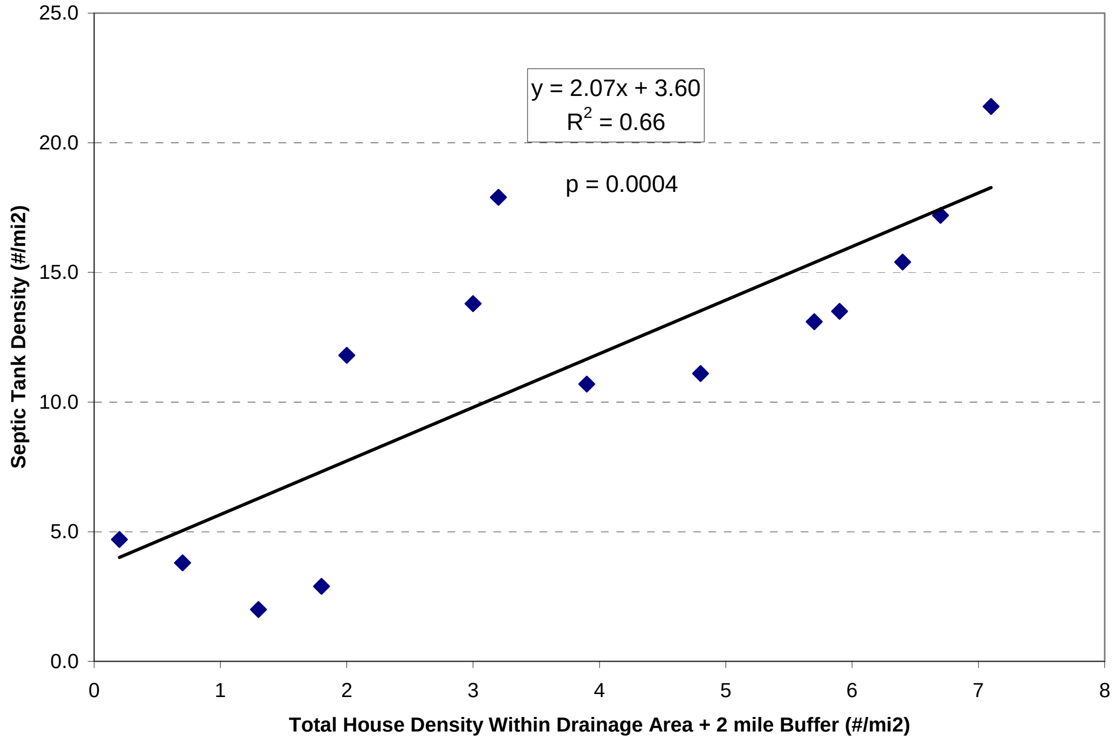


Figure 6.7-3
Cross Correlation Between Septic Tank Density and Poultry Presence

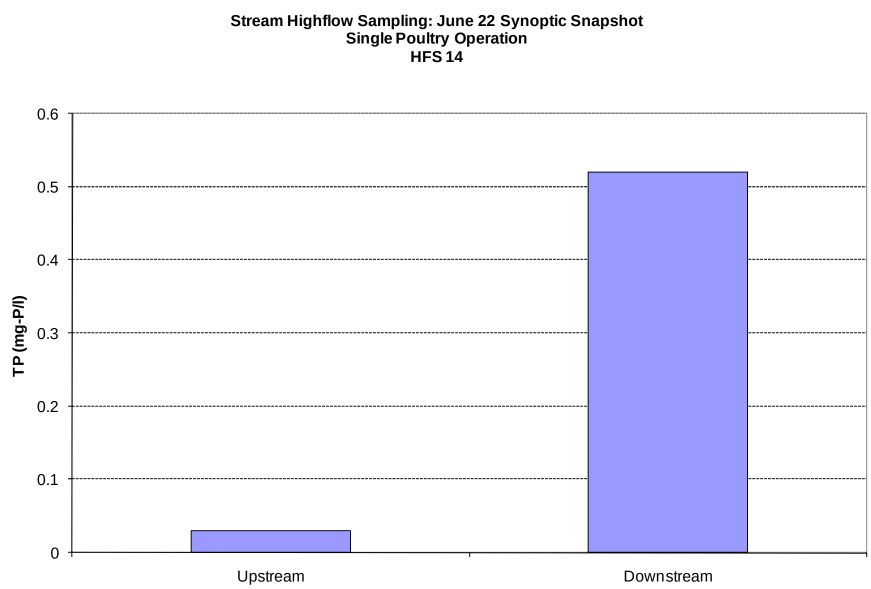


Figure ??
Synoptic Sampling Event Results